



# Organizational capabilities assessment: a dynamic methodology, methods and a tool for supporting organizational diagnosis

Philippe Rauffet, Catherine M. da Cunha, Alain Bernard

## ► To cite this version:

Philippe Rauffet, Catherine M. da Cunha, Alain Bernard. Organizational capabilities assessment: a dynamic methodology, methods and a tool for supporting organizational diagnosis. 2010. hal-00497933

**HAL Id: hal-00497933**

**<https://hal.science/hal-00497933>**

Preprint submitted on 6 Jul 2010

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# **Organizational capabilities assessment: a dynamic methodology, methods and a tool for supporting organizational diagnosis**

Philippe RAUFFET, Catherine DA CUNHA, Alain BERNARD

IRCCyN laboratory – Ecole Centrale Nantes

## **Summary**

Many methods, like CMMI, ISO norms or 5 steps roadmapping, are implemented in organizations in order to develop collective competencies, called also organizational capabilities, around organizational needs. They aim at providing new means to controls resources of organization, and enabling an organizational diagnosis, it is to say the evaluation of the strengths and the weaknesses of the organization. Nevertheless, these methods are generally based on knowledge based models (they are composed of good practices libraries) and on the experience of functional experts who structure these models. So human and organizational errors can occur in these models and noise the assessment of organizational capabilities, and therefore the organizational diagnosis. This paper proposes a methodology, some methods and a tool, to make these knowledge based models and the assessment of organizational capabilities more reliable, so as to enable an accurate organizational diagnosis.

## **Keywords**

Organizational capabilities, Knowledge based models, Assessment, Gaps analysis, Organizational diagnosis

## **Introduction**

Stemming from the Resource Based View theory and the Competitive Advantage approach (Helfat and Peteraf, 2003), Organizational Capability approach looks for optimally exploiting the internal resources to create significant assets for the organization. It aims at developing the aptitudes of organizations, more and more changing in a turbulent environment (Ansof, 1965), by coordinating the progressive learning of corporate good practices by all the organizational entities.

This approach can also help decision-makers in their choice to launch such a new project or reorganization. Regarding the SWOT model from (Learned et al., 1960), it can be therefore considered as a means to diagnose organizational strengths and weaknesses.

Assuming that coordinated organizational practices acquisition induces a better performance, the Organizational Capability approach implements an organizational diagnosis only based on how entities acquire what organization consider as relevant knowledge and how they share it at different levels. This knowledge based assessment allows anticipation in performance management: by evaluating the capabilities of resources, future performance they generate can be estimated, and identified weaknesses can be corrected. Nevertheless, it depends on how organization defines and models the relevant knowledge: if the transferred practices are not enough accurate or adapted to the entities, the organizational diagnosis can be warped, and performance can be not improved even if the evaluation is good.

This paper aims at improving the organizational capabilities assessment. It provides a dynamic method and a tool which takes into account of potential errors in the knowledge based models and verifies if the “potential performance” (given by the knowledge based assessment of organizational capabilities) correspond to the

“expressed performance” (it is to say the results of the activities, the improvement generated by the use of acquired organizational capabilities).

The first part gives an overview of the methods assessing organizational capabilities, points out their limits and proposes a dynamic methodology for improving the evaluation given by the methods of the state of the art. The second section formalizes the assessment models used in the state of the art, and defines the errors which must be identified to improve the assessment reliability. These models and the errors are what the proposed methodology attempt to improve for giving a better assessment. Then the third part presents tools supporting the methodology of the paper, argues on the choices made, and illustrates its use on a case. A fourth section finally provides a framework for using improved assessment to diagnose organizational strengths and weaknesses. Finally a discussion is led to study the interests of the proposed methodology for improving diagnosis reliability, and to open perspectives.

## I. Related works

After defining the concept of organizational capability and its characteristics, assessment methods of the literature are presented as well as their benefits and their limits.

### I.1. Organizational capability concept and characteristics

(Saint-Amant and Renard, 2004) defines organizational capabilities as “know how to act, potentials of action which results from the combination and the coordination of resources, knowledge and competencies of organization through the value flow, to fulfill strategic objectives”.

This definition points out some pregnant characteristics, as emphasized in Figure 1:

- Organizational capabilities constitute therefore the key aptitudes that a company must develop and assess to gain a competitive advantage and to determine the status of its strengths and its weaknesses (de Pablos & Lytras, 2008).
- They emerged from the synergies of organizational resources, which continuously progress thanks to the acquisition of knowledge and competencies (generally modeled under the form of corporate best practices). They are thus related to organizational learning (Lorino, 2001) and knowledge acquisition, as the cause of organizational capabilities emergence, can be an element to assess their development levels.
- Moreover they can be expressed through the value flow, it is to say that the use of organizational capabilities should generate a performance improvement in the activities of organization (Rauffet, 2009). Performance indicators trends, as the results of organizational capabilities emergence, can therefore be clues of their development.
- Finally all the organizational resources are involved in achieving corporate objectives. At a local level organizational capability is the synergy of human, physical and structural resources of an entity around the defined strategic objectives. At upper levels organizational capability is the synergy of entities which developed share the same corporate practices and developed locally the same organizational capability.

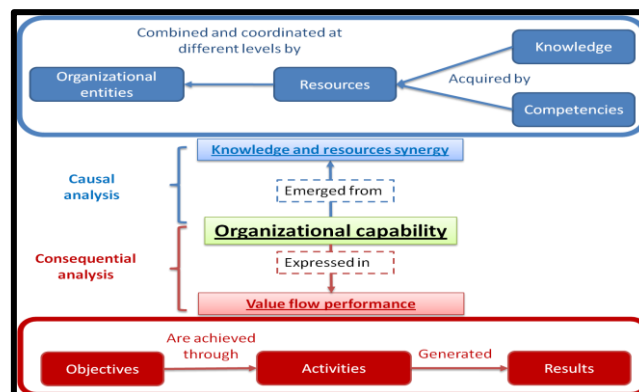


Figure 1: Organizational capability characteristics

## *1.2. Overview of the methods for developing and assessing organizational capabilities*

Over the last decades many methods and tools emerged to manage and assess organizational capabilities. Industrial groups constituted different good practices libraries to make their entities progress on particular concerns (production, information system, purchasing...). Indeed it is necessary to clarify and transmit the knowledge pillars through their extended structures, where communication can be complex due to the numerous interactions and the distance between interlocutors (at geographical, semantic or cognitive levels). Same efforts are also found in national institutions, like the Canadian electronic administration (Saint-Amant, 2004), or in organizations for the development of emerging countries (Lusthaus et al., 2003, Watson, 2009).

From these methods based on the causal analysis (cf. Figure 1) of organizational capabilities, it is to say on the evaluation of knowledge acquisition, two different categories can be distinguished:

- maturity-based methods, which decompose organizational capabilities development according to different progressive steps. For instance, CMMI (SEI, 2010) or 5 steps method (Monomakhoff and Blanc, 2008) use 5 or 6 levels, what enables a progressive learning structure of the different involved resources (gathered in process groups or themes) and allows also providing a kind of metrics to assess organizational capabilities (the minimum maturity level reached by all resources involved).
- coverage-based methods, like ISO (ISO, 2010) or ITIL (ITIL, 2010) methods, which focuses of the acquisition of best practices, without defining an order or a progressive path to develop organizational capabilities. The assessment they propose is more focused on the quantity of practices acquired related to defined conformity triggers in percentage.

These methods introduce changes in performance management.

- First organizations had corrective strategies, based on the monitoring of performance and the solving of apparent issues. They considered that “if they generated good performances for such an activity, then they should have acquired the capabilities associated to this activity”. Organizations focus therefore only on the activities where they have some difficulties, considering that the efficient processes are mastered. This consequential analysis (cf. Figure 1) only focuses on the visible part of performance, it is to say the expression of organizational capabilities.
- In introducing new causal analysis methods, organizations turned their strategies into a systematic preventive mode. They consider now it is necessary to document and boost learning around processes even if these ones are not problematic, to prevent them from a performance decline. So they assume that “if they acquired such a knowledge corpus for such an activity, then they must generate a good performance for this activity”. The maturity- and coverage- based models focus therefore on the immersed part of performance iceberg, it is to say on the management of knowledge and resources synergy which induce organizational capability.

Nevertheless the introduction of this new causal logic raises some barriers.

- Organizational capabilities management allows anticipating the organizational behavior because the diagnosis is based on what induces performance rather than the obtained performance. The danger of this causal knowledge based assessment is that it becomes an “isolated system”, which does not check anymore if the knowledge acquisition generates really a synergy of resources and has an impact on performance. Indeed an only knowledge based assessment can erect the good practices libraries into irrefutable dogma, whereas practices are dynamic and evolving components, that must be updated continuously to keep the assessment reliable.
- Moreover the choice of practices for structuring and modeling organizational capabilities development is only a design assumption (Beguín and Cerf, 2004), which must be refined to correct some imperfections, at the formal work level, with design errors, as well as in the practical application of methods, with transfer errors (Guillevic, 1993).

The anticipation advantages of organizational capability management as indicator of potential performance (causal analysis) should be thus balanced with the reality of organizational performance (consequential analysis).

### *1.3. Limits of the causal analysis models' assumptions: the same barriers than for individual competencies development and assessment*

The limits of the methods presented above for the assessment of organizational capabilities are slightly similar to those ones found in the method for assessing individual competencies. These limits are explained by the formulation of simplifying assumptions, that allow an operational deployment of the competency or the capability, but that can also devalue the information obtained by the assessment.

Methods for developing individual competencies (Berio and Harzallah, 2007; Boucher, 2003; Houé et al., 2009; Boumane et al. 2006; Pépiot et al., 2007) propose an assessment based on the comparison between required competencies and acquired competencies. In the coverage- and maturity-based models (CMMI, 5 steps, ISO, ITIL), the same principle is used to assess organizational capabilities: organizational needs are decomposed into operational requirements, and then the models explain how these requirements can be fulfilled by acquiring a set of good practices (the knowledge models define therefore the capabilities required by the organization). The assessment is done by measuring the acquisition of these good practices by the actors of the organization (that corresponds to the capabilities acquired by the organizational entities).

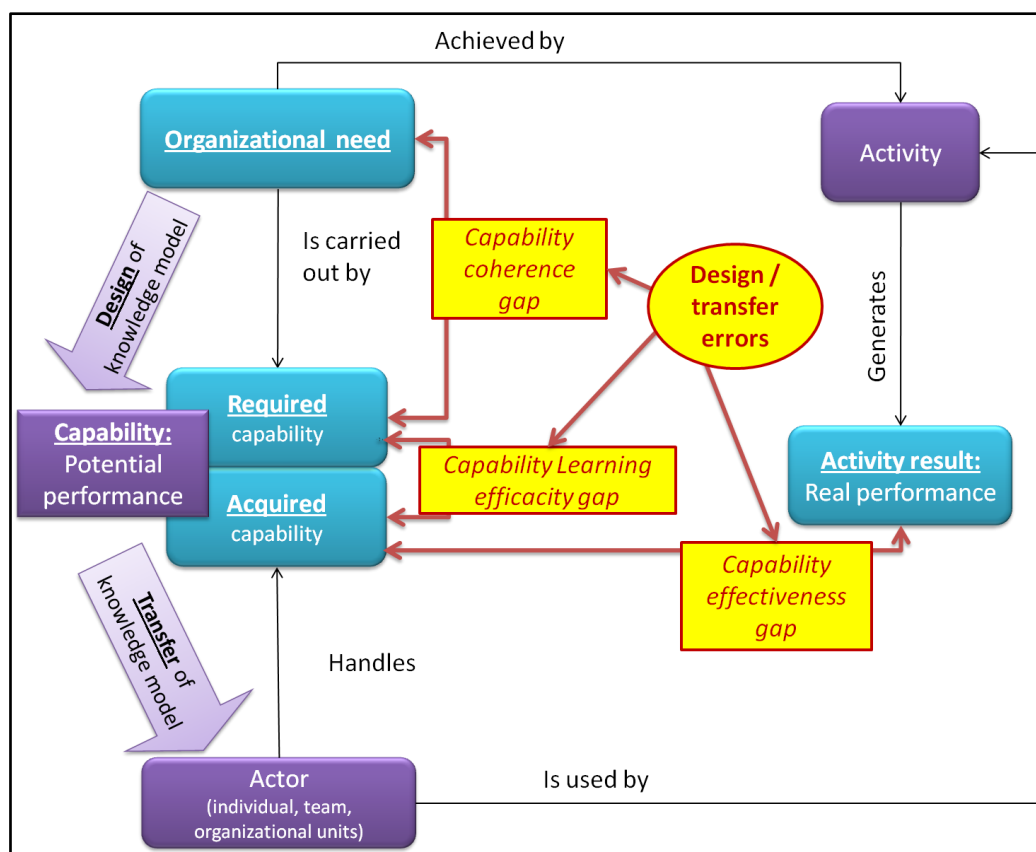


Figure 2: Identification of gaps in organizational capability models due to some design and transfer errors

The assessments of competencies and capabilities follow thus the same principles. However, the organizational capability methods are often presented as standards, as proved norms, which should guarantee a reliable assessment, whereas the individual competencies methods concede that at least two strong assumptions (Harzallah and Vernadat, 2002) must be verified to allow a reliable assessment:

- Competency/Capability coherence: the link between organizational needs and the competencies/capabilities must be correctly and completely described, so as to guarantee the coherence between the mission which must be fulfilled and the required competency expressed in the model and decomposed into knowledge to acquire.

- Competency/Capability learning efficacy: the link between required and acquired competencies/capabilities must be correctly and completely described, in assuming that the transfer and the learning of the competencies/capabilities are made without loss (i.e. the design is robust enough to take into account the context of use, and the transfer is independent from the learning entity and the local context where the entity acquired these competencies/capabilities)

By linking organizational needs to the organizational activities (by considering that the needs are achieved by activities, which use actors acquiring competencies/capabilities), a third assumption is generally implicitly added in the literature models:

- Competency/capability effectivity: there is adequacy between the acquired capabilities (potential performance) and the activities' results (real performance).

Coherence, efficacy and effectiveness are terms used for characterizing the performance, here applied to the concept of capability (cf. Figure 2, yellow rectangular boxes).

The causal models proposed in the literature are thus « ideal » models, which ease the deployment of the organizational capabilities. Nevertheless these models consider as negligible the errors coming from the phases of the design and the transfer of the structure of good practices (cf. Figure 2, yellow circles), and can create some gaps in what it is defined in the paper by capability's coherence, learning efficacy and effectiveness.

The following part aims at studying in details the knowledge based models, so as to extract some generic assessment models, and then to point out the potential errors which can noise these ideal models due to the unfulfilled assumptions characterized above.

## **II. Generic assessment models and introduction of error parameters**

This part formalizes in a generic way how maturity- and coverage-based methods assess organizational capability from knowledge acquisition, then it analyses the potential errors which can occur in these knowledge based assessment models.

### **II.1. Knowledge based assessment models**

The study of knowledge based methods of the literature (cf. I.2) distinguishes some common points, which crosses also the definition of organizational capability (cf. Figure 1):

- Organizational capability can be decomposed according to three knowledge granularity levels: a capability is generally broken down into requirements (objectives of knowledge corpus acquisition), and then into practices (elementary knowledge, means to acquire to achieve requirement). This decomposition structure is found for instance in CMMI method, ISO norms, or 5 Steps roadmapping, or in SMEMP, a maturity model for developing project's organizational capabilities (Gonzalez-Ramirez, 2008).

- Organizational capability can be decomposed according to three resource levels: knowledge are linked with the resource which has to acquire it. A capability is then broken down into some thematic resource groups (5 steps), process groups (CMMI), functional departments, knowledge areas (SMEMP)... and then into elementary human, physical, virtual resources...

- Organizational capability development follows a logic of acquisition, based on maturity objectives (in CMMI or 5 Steps roadmapping) or coverage and conformity trigger (in ISO norms).

These observations allow defining the variables used for formalized both generic maturity- and coverage-based assessment models. For the two models the notion of maturity level is kept, even if the coverage model does not take it into account and could be therefore simplified. That enables to express organizational capability as a function of elementary knowledge with the same variables and the same indices.

Let:

- COx an organizational capability, Ri a resource involved in COx, M the number of COx's resources, N the number of maturity levels of COx, Gy a resource group of COx, and Eij a requirement (a set of knowledge) that Ri has to achieved at the maturity level j
- Kijz an elementary knowledge (a good practice) which is a part of Eij, with Oij the number of Kijz composing Eij. Following "All or Nothing" logic, the acquisition of an elementary knowledge is expressed by:

$$(0) Kijz = \begin{cases} 0 & \text{if } Kijz \text{ not acquired} \\ 1 & \text{if } Kijz \text{ acquired} \end{cases}$$

### II.1.1. Maturity-based assessment models: expression of the evaluation as a function of Kijz

The maturity methods look for coordinating step by step the progress of all resources composing the capability. The maturity level of a resource Ri and an organizational capability COx can be expressed with the following formula and illustrated by Figure 3 (with N=5):

- Let nk a maturity level, with  $nk \leq N$
- Let a(nk,Z) the function a which evaluates if a maturity level nk is activated for each object Z (resource or capability).

$$(1.1) a(nk, Z) = \begin{cases} 0 & \text{if } nk \text{ is not activated} \\ 1 & \text{if } nk \text{ is activated} \end{cases}$$

A requirement Eij is reached if all practices Kijz of the maturity level j are acquired by the resource Ri.

$$(1.2) Eij = \begin{cases} 1 & \text{if } \forall z \leq Oij, Kijz = 1 \\ 0 & \text{if } \exists z \leq Oij, Kijz = 0 \end{cases} \text{ then } Eij = \prod_{z=1}^{Oij} Kijz$$

The maturity level nRi of a resource Ri is given by the sum of resource maturity level activations, it is to say that all practices Kijz of the levels  $nk \leq ni$  must be acquired.

$$(1.3) a(nk, Ri) = \begin{cases} 0 & \text{if } \exists j \leq k \leq N, Eij = 0 \\ 1 & \text{if } \forall j \leq k \leq N, Eij = 1 \end{cases} \text{ then } a(nk, Ri) = \prod_{j=1}^k Eij = \prod_{j=1}^k \prod_{z=1}^{Oij} Kijz$$

$$(1.4) nRi = j / \forall k \leq j \leq N, nRi = 1, nri = \sum_{k=1}^N a(nk, Ri) = \sum_{k=1}^N (\prod_{j=1}^k Eij) = \sum_{k=1}^N (\prod_{j=1}^k \prod_{z=1}^{Oij} Kijz)$$

The maturity level nx of a capability COx is given by the sum of capability maturity level activations, it is to say that all practices Kijz of the level  $nk \leq nx$  must be acquired for all resources Ri composing the capability.

$$(1.5) a(nk, COx) = \begin{cases} 0 & \text{if } \exists i \leq M, a(nk, Ri) = 0 \\ 1 & \text{if } \forall i \leq M, a(nk, Ri) = 1 \end{cases} = \begin{cases} 0 & \text{si } \exists j \leq M, \exists j \leq k \leq N, Eij = 0 \\ 1 & \text{si } \forall i \leq M, \forall j \leq k \leq N, Eij = 1 \end{cases}$$

$$\text{then } a(nk, COx) = \prod_{i=1}^M a(nk, Ri) = \prod_{i=1}^M \prod_{j=1}^k Eij = \prod_{i=1}^M \prod_{j=1}^k \prod_{z=1}^{Oij} Kijz$$

$$(1.6) nCOx = j / \forall k \leq j \leq N, a(nk, COx) = 1$$

$$nCOx = \sum_{k=1}^N a(nk, COx) = \sum_{k=1}^N (\prod_{i=1}^M a(nk, Ri)) = \sum_{k=1}^N (\prod_{i=1}^M \prod_{j=1}^k Eij) = \sum_{k=1}^N (\prod_{i=1}^M \prod_{j=1}^k \prod_{z=1}^{Oij} Kijz)$$

COx	n1	n2	n3	n4	n5
R1	E11 K111 ... K11011	E12	E13	E14 K141 K142 K143	E15
...					
Ri	Ei1		Ei3		Ei5
...					
RM	EM1		EM3		EM5
The grey Eij mean that all their Kijz are acquired So nR1=3; nRi=5; nRM=4; nCOx=2					

Figure 3: Illustration of resource and capability maturity level assessment (N=5)

### II.1.2. Coverage-based assessment models: expression of the evaluation as a function of Kijz

Coverage-based methods look for the progress of resources towards a conformity trigger. There is no more concern about maturity, but about quantity, coverage of acquired practices. Different logics can be applied.

Capability can be considered globally, or each resource can be studied to check if it reaches a sufficient local coverage of practices.

The coverage of a resource  $R_i$  and an organizational capability  $CO_x$  can be expressed with the following formula and illustrated by Figure 4 (with  $N=5$ ):

- Let  $cCO_x$  the coverage of an organizational capability  $CO_x$ , and  $cR_i$  the coverage of a resource  $R_i$ .

To determine how a requirement  $E_{ij}$  is reached, the All or Nothing logic of (1.1) can be kept, but the coverage logic can also be further applied by removing the requirement granularity level, and expressing the coverage levels by counting only the number of acquired practices on the number of existing practices ( $E_{ij}$  becomes therefore a percentage). In this case, the coverage model becomes a simple addition of checklists of the different resources composing the capability.

$$(2.1) E_{ij} = \begin{cases} 1 & \text{if } \forall z \leq O_{ij}, K_{ijz} = 1 \\ 0 & \text{if } \exists z \leq O_{ij}, K_{ijz} = 0 \end{cases} \text{ then } E_{ij} = \prod_{z=1}^{O_{ij}} K_{ijz} \text{ or } 0 \leq E_{ij} \leq 1 \text{ then } E_{ij} = \sum_{z=1}^{O_{ij}} \frac{K_{ijz}}{O_{ij}}$$

The coverage  $cR_i$  of a resource  $R_i$  is given by the amount of reached  $E_{ij}$  on the number of existing requirements for this resource (that corresponds to the number of maturity level of capability, since the maturity structure is kept for comparing maturity an coverage models)

$$(2.2) cR_i = \sum_{i=1}^N \frac{E_{ij}}{N} \text{ (local coverage)}$$

The coverage  $cCO_x$  of a capability  $CO_x$  is given by the total of reached  $E_{ij}$  on all existing requirements of the capability.

$$(2.3) cCO_x = \sum_{i=1}^M c_i = \sum_{i=1}^M \sum_{j=1}^N \frac{E_{ij}}{M \times N} \text{ (global coverage)}$$

CO <sub>x</sub>	n1	n2	n3	n4	n5
R1	E11 K <sub>111</sub> ... K <sub>11O<sub>11</sub></sub>	E12	E13	E14 K141 K142 K143	E15
...					
R <sub>i</sub>	E <sub>i1</sub>		E <sub>i3</sub>		E <sub>i5</sub>
...					
RM	EM1		EM3		EM5

*The grey E<sub>ij</sub> mean that all their K<sub>ijz</sub> are acquired (All or Nothing logic)  
So cR1=80%; cRi=100%; cRM=80%; cCOx=72%*

*If not completed E<sub>ij</sub> are considered  
(example with E14 and O<sub>ij</sub>=3 for each E<sub>ij</sub>)  
Then cR1=93,3%, and cCOx=74,6%*

Figure 4: Illustration of resource and capability coverage assessment (N=5)

### II.1.3. Comparison of maturity- and coverage- based assessments

The maturity assessment introduces the notions of order, of learning path. It insists therefore on the step by step progress, and rewards coordinated and synchronized (among all resources) knowledge acquisition, almost as points are counted in sjoelbak game, a dutch variant of shuffleboard. To the contrary coverage assessment takes all practices acquisition into account (or at least of the requirements reached) to assess capabilities and resources states. But the learning path disappears, and it can be pregnant to keep (a practice can be valuable only if another practice is acquired before, in a conditional manner). The two assessments can be thus used independently, to express two different ways to acquire knowledge. However the choice of the assessment has some impacts in the way of learning of entities: with the maturity methods, learners are more focused on mastering homogeneously their resources, without exploring the practices proposed at upper maturity levels, whereas the coverage methods incite people to explore all the practices they can acquire. Moreover only maturity assessment provides a meaningful metrics for organizational capabilities: maturity levels are given according to a structure established for developing capabilities, whereas coverage percentages are difficult to analyze, except from showing how organization and its entities are from the complete acquisition of the



capabilities. The first one can be therefore considered as an indicator for organizational diagnosis, and the second one is more adapted to inform learners and boost them.

These previous paragraphs provide a generic modeling on how maturity- (CMMI, 5 steps...) and coverage- (like ISO norms) assess organizational capabilities by using the measurement of elementary knowledge acquisition. The next section analyses hereafter which errors can occur within these models.

## **II.2. Potential errors in knowledge based models**

Part I pointed out the limits of knowledge based models, by especially arguing that the assumptions they used make them « ideal », sometimes not enough fitting the reality. It is therefore necessary to consider the existence of some error parameters, by considering that the knowledge acquisition structure is only a design hypothesis, and so there is no perfect a priori model. This section analyzes the potential errors which can exist in knowledge based models, in the design phase (when organizational capability is modeled by organization by structuring the best practices) and in transfer phase (when organizational capability are taught to entities, to develop their skills on strategic subjects).

### **II.2.1. Design error parameters**

#### **$\epsilon R_m$ – error in the structure of resources**

The parameter  $\epsilon R_m$  represents a design error which can come from a too complicated (there are too many resources, some resources could be combined in one) or too simplistic structure (the resources composing organizational capability are not enough sufficient).

#### **$\epsilon K_n$ – error in the structure of knowledge**

The parameter  $\epsilon K_n$  can only be present in a maturity model (due to the learning path it proposes, contrary to the coverage model). It represents a design error which can occur if:

- the practices  $K_{ijz}$  are not sufficient or not well structured to reach the requirement  $E_{ij}$ .
- the practices  $K_{ijz}$ , or at an upper level the requirements  $E_{ij}$  are not well ordered. Indeed if there is a bad permutation, knowledge acquisition can have limited effect on performance or it can even be blocked:
  - if two practices are too far from each other, in time or in structure, the memory effect of the learning path can be dissipated
  - If the learning path is not optimal for the learning context. For instance, teaching theory before practice can work for some people who figure abstract concepts, but practice before theory is sometimes more understandable for operational people.
  - if there is a conditional link between two practices or requirements, if the first one is modeled in the structure after the second, the organizational capability development are stuck.

### **II.2.2. Potential transfer errors in the knowledge based models**

#### **$\epsilon R_m'$ – error of contextualization in the structure of resources**

The parameter  $\epsilon R_m'$  represents the error when the context of application does not fit with the practices modeled in the model. Some resources can be not present in the operational ground, or not decomposed in the same way than in the theory. The users are then in difficulty to assess their progress, or to use the assessment to diagnose the organizational status. If an error appears for all entities, then it becomes a design error.

#### **$\epsilon K_n'$ – error of contextualization in the structure of knowledge**

The practices or requirements which must be acquired are not relevant for such an entity, which can notify that by declaring the knowledge not applicable. If this error exists for all entities, it becomes also a design error.

#### **$\epsilon A$ – error in assessment**

This represents the errors which can occur in the assessment (human error for instance) and can cause interference on the obtained maturity level or coverage.

Some parameters can be estimated, by studying the complexity of the structure ( $\epsilon R_m$ ), the adequacy between what the model proposes and what there is on the operational ground ( $\epsilon R_m'$  and  $\epsilon K_n'$ ), or the speed of learning (to identify some blockage points, like the conditional link error presented in  $\epsilon K_n$ ). Another way to reinforce the error estimation and to evaluate the other parameters (like  $\epsilon A$  or the amount of necessary practices in a requirement) is to compare organizational capabilities assessments and performance indicators.

This part formalized the knowledge models in a generic way and enlisted the errors which can noise these “ideal” models. The following paragraphs propose therefore a methodology to improve the reliability of knowledge based assessment methods, based on the mix of causal and consequential analysis, before providing some methods and tools to estimate, detect and correct the identified errors.

### **III. Proposition for an approach to reliably assessing organizational capabilities**

In order to overcome the identified barriers presented above, a methodology is proposed and then used to build methods and a tool, which are presented in a later part of this paper.

#### **III.1. Assumptions**

- **Knowledge-based assessment**: The modeling structure of literature methods enables an evaluation of organizational capabilities. A capability can be therefore assessed in measuring the acquisition of knowledge/competencies by organizational entities. This point is developed and formalized in paragraph II.1.
- **Causality**: The development of an organizational capability can be expressed by an improvement on organizational performance indicators. There is thus a causal link between capabilities (what organization is able to do) and the results (what organization achieves). This assumption is time-dependent, there can be a delay, a ramp-up phase between the acquisition of knowledge and the expression of the capability.
- **Equivalence**: A capacity level (maturity-based methods) or quantity (coverage-based methods) must fit with a performance level. So there is a kind of equivalence between a potential performance and an expressed performance.
- **Design and transfer errors existence**: The modeling or the application of the knowledge model on the local ground can generate some errors in design (the model do not induce wished performance) and transfer (model is not adapted to such contexts) phases. Some error parameters exist, and the proposed methodology must take into account of them to verify the previous assumption.

#### **III.2. Proposed methodology**

The current proposition looks for improving the reliability of organizational capabilities assessment, by using the previous assumptions. The methodology is illustrated in Figure 5, around the knowledge based assessment methods which are represented in the dotted box and are formalized in II.1.

##### **Step 1. Impacts analysis of organizational capabilities on performance**

By crossing the set of organizational capabilities assessment with performance indicators (it is to say the evaluation of the use of capabilities), causal links between « potential » and « expressed » performances can be determined. This first step is used to find the performance criteria necessary to study the behavior of each capability.

##### **Step 2. Errors identification for one organizational capability**

The errors which can deteriorate the assessment of an organizational capability can be analyzed according to two different processes:

- **step 2.1. Internal errors estimation, by analyzing “coherence and learning efficacy gaps”**: The errors can be identified only by studying the complexity of the structure or the knowledge acquisition speed of an organizational capability (cf. IV.1.1.).
- **step 2.2. Errors detection by analyzing “effectiveness gap” (cf. Fig.2) between knowledge based assessment and performance results**: Errors can be detected by comparing statistically, on all the learning entities, the

capability evaluation according to the level on the associated performance indicators obtained in the first phase of impacts analysis (cf. IV.1.2.).

### Step 3. Errors minimization for one organizational capability:

The errors identification generates some actions on how one organizational capability is assessed:

- step 3.1. *Indicative assessment improvement:* The feedbacks given by the phase of errors identification allows alerting managers with a trust trigger that such a capability on a specific application perimeter has an error.
- step 3.2. *Corrective model improvement:* If identified errors concern some issues about organizational capability design, the model can be improved, to enable a more accurate organizational capability assessment.

### Step 4. Aggregation / Consolidation of assessment:

The assessment of organizational capabilities and performance indicators given by each organizational entity are aggregated and consolidated, to enables (and then improve, along the time) the phase of impacts analysis, and rather help managers to diagnose more reliably their organizational capabilities, whatever the organizational level studied. Some adapted organizational capabilities indicators can be built from the local assessment (cf. IV).

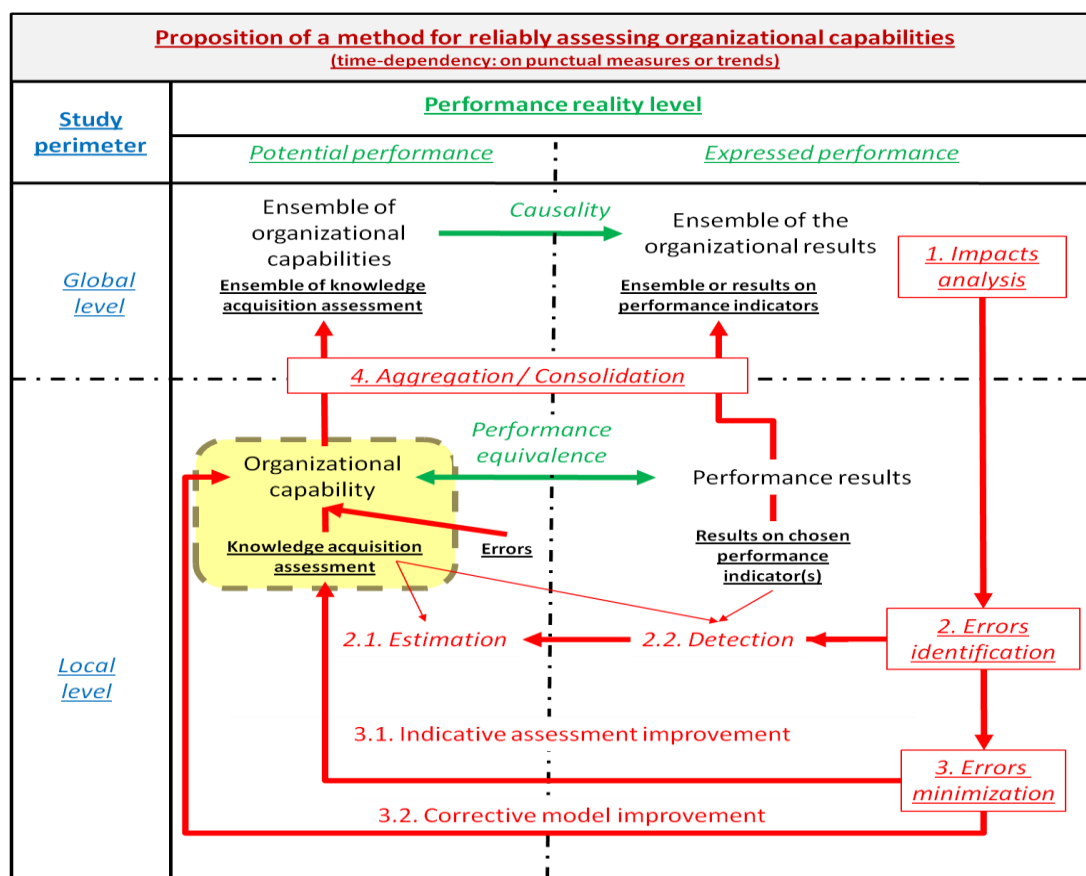


Figure 5: Methodology for improving reliability of organizational capabilities assessment

This first part reminds the different concepts and methods related to organizational capabilities. The different strategies for assessing capabilities are given and formalized in the Figure 1. The limits of the separated use of causal and consequential analysis are discussed, and the methodology illustrated in Figure 2 is proposed to overcome these limits, by combining them together. This proposition is supported by some formal models and some tools, which are presented in the following paragraphs.

## IV. Methods and tools for identifying errors and improve assessment reliability

This part explains and justifies the methods and tools developed for improving organizational capability assessment, and it then shows how they can be used in the context of an extended organization. It focuses on the steps 1 (impacts analysis), 2 (errors identification) and 3 (assessment improvement) of the proposed methodology.

#### IV.1. proposition of methods

A part of the methodology proposed in part I.3 (all excepted the step on the use of reliable assessment for data aggregation and consolidation) is illustrated more in detail on the Figure 6. In this model, errors can be found by:

- estimation, by observing the structure or the learning speed.
- or by detection, in comparing the results of knowledge acquisition and the results of chosen performance indicators (provided by an impacts analysis), to check if the development of organizational capabilities has tangible impact on the results of organizational activities.

The identification of the errors present in the knowledge based models can be based on:

- the information about the structure of the model (by studying if it is well balanced, if it has a good granularity level...)
- the information about the learning behavior of the model, given by the feedbacks (in natural language) of people who implement the organizational capabilities in their context (about their misunderstanding of what organization requires to them...) as well as some elements of measurement:
  - the evaluation of organizational capabilities by each entities (which assess themselves their progress) and their behavior according to the time (to detect blockage points, of good entities to point out as example)
  - the declaration by some entities that a practices, a requirement or a resource is not applicable, it is to say that they cannot be assessed for these entities
  - the audit reports, which provide another source of evaluation than the self-assessment by entities on the same knowledge based models, and which enables to detect the not accurate assessment.
- the information about the behavior of each organizational capability according to its function, given by the values of performance indicators, which provides an image of what acquired organizational capabilities cause, as well as a comparison criteria to study each capability (after an impact analysis).

Once the error is identified, it can be characterized by considering its range. If the error is related to the model's structure, or if it concerns all the entities in general, then it is a design error, and the model should be modified, to enable an accurate assessment and a reliable organizational diagnosis. If the error is only present for some entities, it is a transfer error, and either an effort must be done to help the entities in difficulty to achieve the progress as it is modeled, or the model can be specifically adapted to the entities, by giving a feedback on the degradation of the assessment (given that the model is not exactly the same than for the rest of the organization). In this case, the data on the context of application are used to determine the cause of the failure.

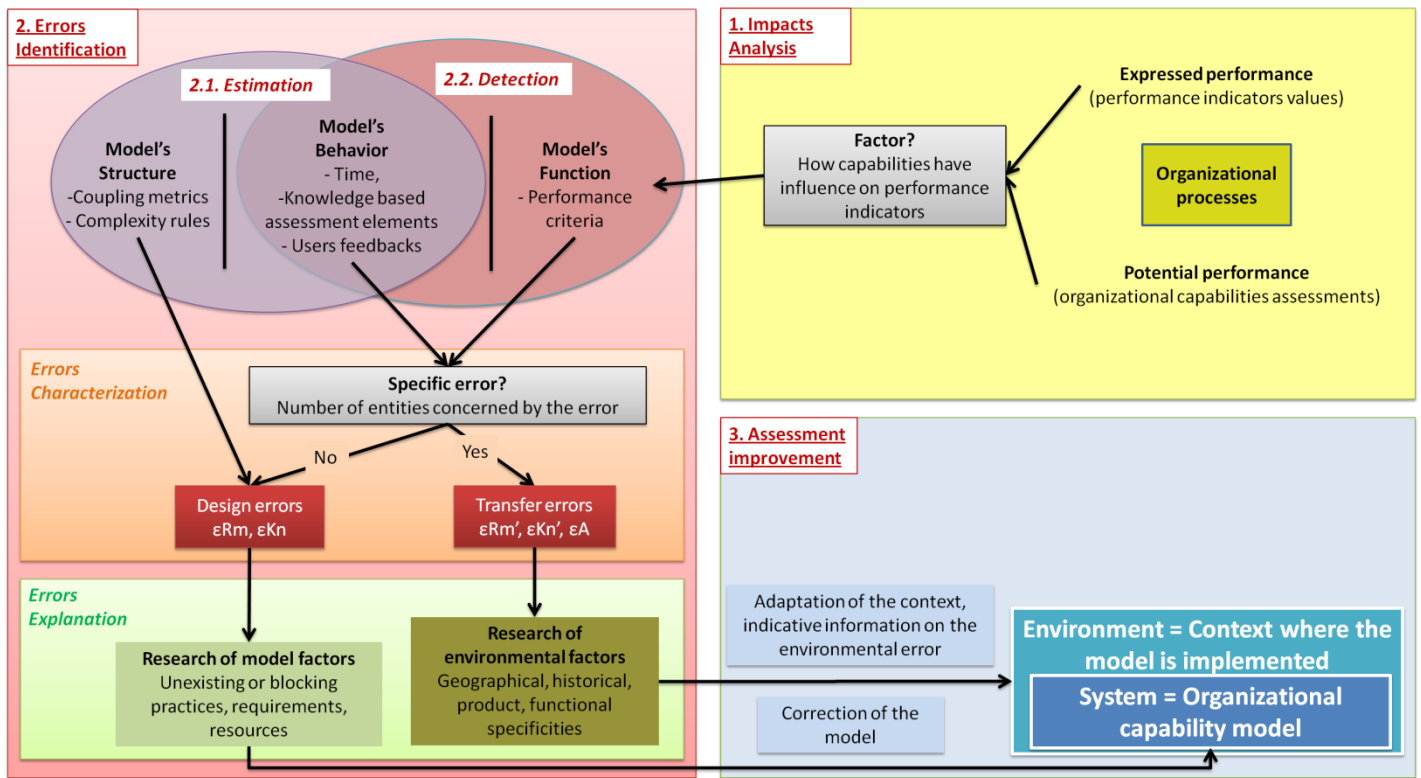


Figure 6: Details on errors identification processes and used information

#### IV.1.1. Methods for internal errors estimation (analysis of the coherence and the learning efficacy of knowledge based models)

These estimation of errors only uses the information about the structure of the model (in a static and off-line way) and about the learning behavior (in a dynamic and on-line way, when entities acquire knowledge and give feedbacks, either by their assessment or by their recommendations).

##### Analysis of the model's structure for estimating $\epsilon R_m$ and $\epsilon K_n$

The parameter  $\epsilon R_m$  can be estimated in studying the complexity of the structure of the resources involved in the organizational capability development.

##### Design rules for $\epsilon R_m$ and $\epsilon K_n$

Some methods recommend rules for helping the design of an organizational capability, with a good granularity level and with all the necessary resources to its development. If a model does not match the “normative” recommendations of the methods, therefore an error in the structure of resources exists.

In the domain of process modeling, IDEF0 considers that a process is decomposed with a good granularity level if, at each levels, the number of activity diagrams is between 3 or 6.

In the same way, some organizational capabilities methods provide some modeling principles: for instance, 5 steps method propose to decompose organizational capabilities from 5 to 10 resources, so as to present the multi-disciplinary dimension of the problem without losing learners by too many details. The parameter  $\epsilon R_m$  can be therefore determined by the distance to this interval. In the same manner, some design rules could be proposed to recommend a good granularity level of requirement (and so estimate  $\epsilon K_n$ ), by suggesting the number of practices which should compose it.

These design rules are very simple to implement, but they are based on the experience of experts, it is to say the people who design the organizational capabilities (some would say the rules come from good sense, some others would emphasize the subjectivity of these rules).

##### Structuring groups of resources for $\epsilon R_m$

Some methods, like CMMI, project maturity models based on PMBoK, or 5 steps method, propose lists of process domains, knowledge areas or themes to guarantee a multi-disciplinary capability. Indeed, if a company wants to develop a capability for the adoption of a new software by all the employee, it will of course require technical resources (people, methods and tools for purchasing, installing on computers, administrating...), but

also other resources (people methods and tools for communicating about the new implemented software, training the employees, collecting the feedbacks and helping people who meet difficulties), to sustain an effective adoption.

#### Coupling metrics for $\epsilon Rm$

Another way to determine the parameter  $\epsilon Rm$  is found in the works about system coupling. If the resources and their potential links between them are known, coupling metrics can be calculated, and resources can be rearranged according to them.

The parameter can therefore estimated by:

$$\epsilon Rm = \sum_{Si} \frac{\left( \frac{\text{Used couplings}}{\text{Possible couplings}} \right)_{Si} - \left( \frac{\text{Used couplings}}{\text{Possible couplings}} \right)_{Si \rightarrow Sj \neq Si}}{nbSi}$$

with  $Si, Sj$  potential combination of resources  $Ri, Si \rightarrow Sj$  couplings between these combinations, and  $nbSi$  the number of considered combinations

Some resources can be thus combined in one, or in the contrary one resource can be decomposed in several ones, to optimize the resource structure into well-sized modules, and avoid the unintentional behavior of the implemented organizational capability (Autran et al., 2008).  $\epsilon Rm$  has a value between -1 and 1. More it is close to 1, more the combinations are independent from each other and more the unintentional behavior of the resources are limited.

For instance let three resources R1, R2, R3 with the links represented in the Figure 7. The parameter  $\epsilon Rm$  indicates that there is only one solution (R1 combined with R2 into one resource) better than a structure where R1, R2, and R3 are modeled separately. The structure could be therefore rearranged (according its meaning, this parameter is only a tool for helping the designer), and the practices recombined to fit the new resource. That enables to avoid divergent learning from the two linked resources R1 and R2.

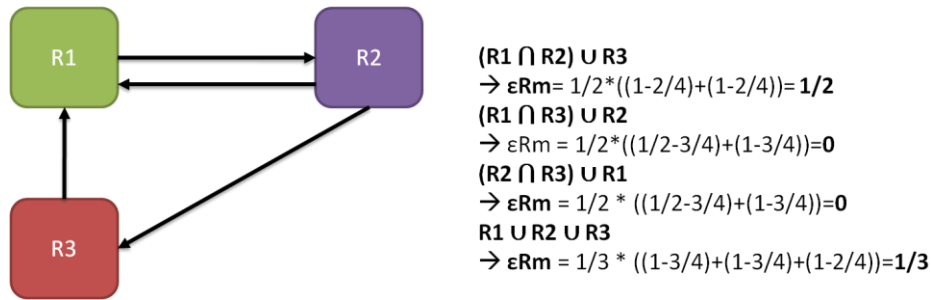


Figure 7: Calculation of  $\epsilon Rm$  for determining the best structure of resources

#### Analysis of the model's behavior for estimating $\epsilon Kn$ , $\epsilon Kn'$ , $\epsilon Rm$ and $\epsilon A$

Because the coverage models do not introduce the notion of learning path, practices can be acquired without following a structure. At the opposite, the maturity methods impose an order to acquire knowledge, so an error in the structure of knowledge can occur in this case.

#### Use of the "learning speed" for $\epsilon Kn$ , $\epsilon Rm$ , $\epsilon Kn'$ , $\epsilon Rm'$

- To estimate the parameters  $\epsilon Kn$  and  $\epsilon Rm$ , the behavior of organizational capability according to the time can be studied. If there is a stagnation of the maturity level at a global level of the organization, that means there is a sticking point, at least a practice, which cannot be acquired and block the progression of the capability.

The error can be therefore estimated by the rate of change given by:

$$\epsilon Kn (\text{global error}) = \sum_{x \leq nbsites} \frac{nCOx(t+T) - nCOx(t)}{nbsites \times T} \text{ and } \epsilon Rm (\text{global error}) = \sum_{x \leq nbsites} \frac{nRi(t+T) - nRi(t)}{nbsites \times T}$$

with  $t$  the instant of the first assessment,  $T$  a period of time

and  $nbsites$  the number of sites developing the considered organizational capability

It corresponds to the learning speed of organizational capabilities. More this rate is close to 0 or even negative (in this case, that means some practices are lost by learners), more the error is significant.

- The parameters  $\epsilon Kn'$  and  $\epsilon Rm'$  means there is no error in the model design (the « generic » resources are accurate for developing the organizational capabilities) but some practices, some requirements, or some resources of the model can be not relevant for some specific context. There is therefore an error at a local level. The previous solution can be adapted to estimate the parameters  $\epsilon Kn'$  and  $\epsilon Rm'$ , by observing the stagnation

for each entity, to compare the rate of change of one learner from the others, so as to determine which entity meets some sticking point.

$$\varepsilon Kn'(local\ error) = \frac{nCOx(t+T)-nCOx(t)}{T} \text{ and } \varepsilon Rm'(local\ error) = \frac{nRi(t+T)-nRi(t)}{T}$$

with  $t$  the instant of the first assessment,  $T$  a period of time

Use of the “users’ feedbacks” for  $\varepsilon Kn$ ,  $\varepsilon Rm$ ,  $\varepsilon Kn'$ , and  $\varepsilon Rm'$

Another means is to use the feedback of users. For instance, in 5 steps methods, people who assess organizational capabilities can declare if a practice, a requirement or a resource is applicable or not to their context.

The NA declarations (“not applicable”), on a practice, a requirement or a resource can mean a design or a transfer error, depending on the number of entities which declare it. More the NA are numerous on a practice, more the error is due to the design. Moreover, some NA feedbacks can be aggregated to deduce some NA not declared. For instance, if a resource presents too many requirements of practices not applicable, then the resource should be considered as not applicable too. Indeed, how such a resource could be taken into account if the essence of the knowledge which must be acquired for developing the organizational capability is not relevant for the context?

These NA feedbacks provide also some indications on the strength of the organizational capabilities assessment given by each entity. An organizational capability assessed with many NA by an entity is more difficult to compare than a capability acquired by an entity where the context matches the assumption of the model.

Use of a “double check” assessment for  $\varepsilon A$

Finally the error due to a not accurate assessment can be estimated by some audit campaigns, which enables to compare the assessment given by the entity from the auditors’ assessment on the same organizational capability model. These actions correct the potential error of assessment, and could also give a feedback for designers. Some practices or some resources can be not well acquired because they are not understandable by some or all entities.

#### **IV.1.2. Methods for error detection (by analyzing the effectiveness of knowledge models on the activities performance)**

The previous methods of error estimation only study the internal structure or behavior of the organizational capability model. So as to check if knowledge based assessment models are reliable, it is also necessary to determine by another way the value of organizational capabilities. This other means is to compare the value given by the acquisition of knowledge (what induces the organizational capability) with the value given by organizational performance indicators (what is expressed by the organizational capability).

Let assume that major part of organizational capabilities and performance indicators are shared by all the entities. In this framework variables can be posed. Let:

- $\{COx\}$  the list of  $x$  shared capabilities  $COx$ , with a grade  $gCOx$  (maturity level  $nCOx$  or coverage  $cCOx$ ),
- $\{IPy\}$  the list of  $y$  performance indicators  $IPy$ ,
- $\{Pz\}$  the list of  $z$  entities’ properties: they can deal with the product types delivered by an entity, the geographical zone, the seniority in group, or also the level of an entity in the language used by organizational capabilities.
- $\{Ei\}$  the list of  $i$  entities  $Ei$  defined by a name or a code  $Ni$ , the list of its properties  $\{Pz\}_i$ , the list of its grades on the  $x$  organizational capabilities  $\{COx\}_i$ , the list of its value for the  $y$  performance indicators linked with the production system  $\{IPy\}_i$ .

#### **Impact analysis for detecting global design errors and finding comparison criteria**

First, it is necessary to find the performance indicators associated to the implemented organizational capabilities. They can be known or chosen a priori by the experts (for instance an organizational capability model on the maintenance could certainly be linked with the number of machine failures), or determined by studying the statistical dependency between organizational capabilities assessment (based on knowledge models) and performance indicators. This statistical analysis can be led as below:



• Let us consider the sample  $\{E_i\}$  composed of all the entities  $E_i$ . The goal in this first stage is to find, in a natural and causal way, for all  $IP_k$  from  $\{IP_y\}$ , the relation which links the performance indicator to all the organizational capabilities of  $\{CO_x\}$ , such as:

$$IP_k = \sum_{i=1}^x a_{ki} \times gCO_i, \text{ with } \sum_{i=1}^x |a_{ki}| = 1$$

The coefficient  $a_{ki}$  are normalized (so as to measure the impact of a capability on  $IP_k$  in comparison with the other capabilities), but they can vary between -1 and 1 (in order to take into account their positive or negative effect on the performance).

• To find the  $a_{ki}$ , many tools exist like the multiple linear regression MLR, or some statistical methods which test the statistical dependence between two variables (Mutual information, coefficient of Pearson, covariance, etc). In assuming that MLR method is chosen, the following formula can be written:

$$IP_k = \sum_{i=1}^j A_{ki} \times gCO_i + B + e,$$

with  $A_{ki}$  the MLR coefficients,  $B$  a constant and  $e$  the regression error.

If  $e$  is acceptable, the  $a_{ki}$  can be deduced from the  $A_{ki}$  by normalizing them:

$$a_{ki} = \frac{A_{ki}}{\sum_{l=1}^j |A_{kl}|}$$

• Once this transformation done for the  $m$  performance indicators, the linear system is:

$$\begin{bmatrix} IP_1 \\ IP_2 \\ \dots \\ IP_y \end{bmatrix} = \begin{bmatrix} a_{11} & \dots & a_{1x} \\ \dots & \dots & \dots \\ \dots & \dots & \dots \\ a_{y1} & \dots & a_{yx} \end{bmatrix} \begin{bmatrix} gCO_1 \\ \dots \\ gCO_x \end{bmatrix}$$

This system enables to have a global understanding of the impact of capabilities on group performance.

• In studying the matrix of this linear system, the list of significant performance indicators which represents the importance of each  $CO_k$  from  $\{CO_x\}$  can be extracted. The user has firstly to pose a threshold  $T$  from which he considers a capability plays a significant role on the performance indicators, for instance  $T=25\%$ . Then the list of significant performance indicators associated to  $CO_k$  is:

$$\{\text{SignifIP}(CO_k)\} = \{IP_j \text{ such as } |a_{kj}| \geq T\}$$

This kind of analysis can even somehow meet the Knowledge Value analysis of (Yang, 2009).

• Thus organizational capability (composed of the transferred good practices and represented by the capability) has a value which can be determined by the performance it generates on the whole group, expressed by:

$$\text{Value}(CO_k) = \sum_{i=1}^j b_{ki} \times IP_i,$$

$$\text{with } b_{ki} = \begin{cases} 0 & \text{if } |a_{ji}| < T \\ a_{ji} & \text{if } |a_{ji}| \geq T \end{cases}$$

This impact analysis has a twofold role:

- Determining the impacts, the “real” effect of organizational capabilities (what entities learns to develop an organizational capability): this analysis enables therefore to identify some unknown primary effects or some secondary effects of the capabilities, positive or negative for the organization, and allows the detection of some design errors ( $\epsilon R_m$  and  $\epsilon K_n$ ) in the models. Indeed, the results of the impact analysis means that the negative effects or the not enough good effects on some performance indicators are global, whatever the context.
- Providing the comparison criteria (it is to say the associated performance indicators) for analyzing independently each organizational capability, comparing entities between them and detecting local transfer errors.

### **Statistical comparison for detecting local transfer errors**

Once the impact analysis is made, it is possible to the behavior of the acquisition of a capability by each entity according to a criterion chosen among the associated performance indicators. This statistical study aims at



emphasizing the potential singularities, which can mean some error in assessment  $\varepsilon A$  or some contextual errors ( $\varepsilon Rm'$  and  $\varepsilon Kn'$ ) due to a difference between what the model proposes and what the entity's context is. To achieve this statistical analysis, the assumptions on the equivalence and the causality (expressed in paragraph 1.31) must be used.

- The equivalence between a level of organizational capability  $COx$  (maturity or coverage) and a level of performance indicator  $IPy$  does not mean that the points (representing the values obtained by each entity on the capability maturity and the performance indicator) belong to a monotonous function, but it indicates that at least the intervals (represented the performance and capability levels, and illustrated by the three rectangles on Figure 8) are in bijection.

Let  $(gCOx_i)$  a subdivision of  $[gCOy_{min}; gCOy_{max}]$  and  $(IPy_i)$  a subdivision of  $[IPy_{min}; IPy_{max}]$

Let  $IntCO$  and  $IntIP$  the spaces of intervals given by these subdivisions

then  $\exists f$  a bijective function from  $IntCO$  to  $IntIP$

i. e.  $\forall [IPy_i; IPy_{i+1}] \in IntIP, \exists! [gCOx_i; gCOx_{i+1}] \in IntCO$  s. t.  $[IPy_i; IPy_{i+1}] = f([gCOx_i; gCOx_{i+1}])$

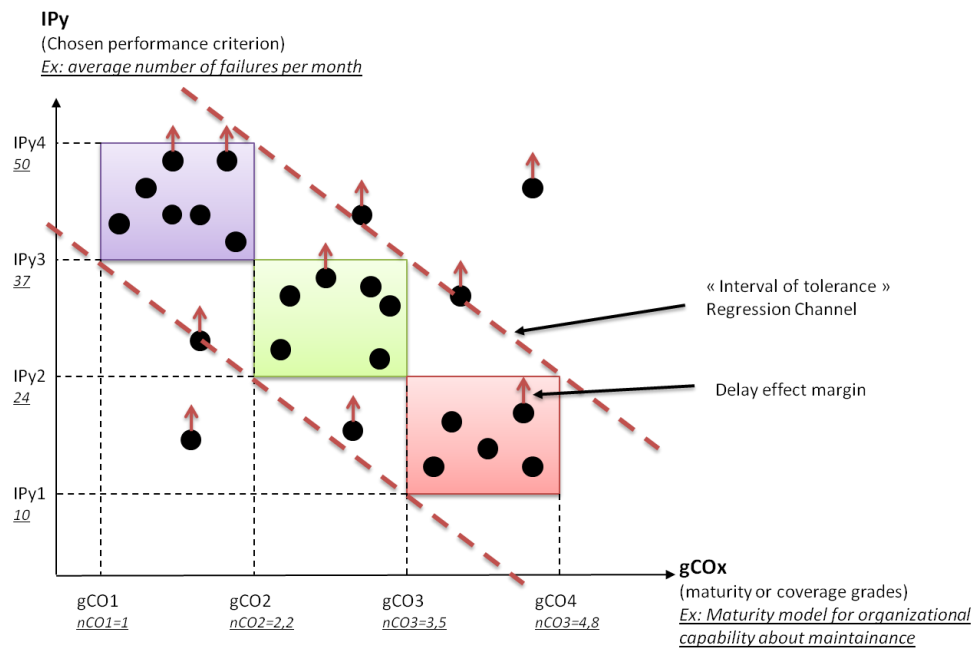


Figure 8: Detection by using equivalence assumption

With this assumption of equivalence, the points out the boxes can therefore be considered as singularities, where there are obviously transfer errors. The parameters  $\varepsilon Rm'$ ,  $\varepsilon Kn'$  and  $\varepsilon A$  can thus be calculated by the distance to this boxes. Nevertheless this method raises some difficulties, especially on the way to determine the triggers between two consecutive levels (for performance and capability).

- The causality between organizational capabilities and performance induces that if  $gCOx$  increases on a period  $[t1; t1+\Delta T]$ , then  $IPy$  increases (or decreases, according to the monotonous relation between  $COx$  and  $IPy$ ) on a period  $[t2; t2+ \Delta T']$ . In some other words, this means that  $\frac{IPy_{t2+\Delta T'} - IPy_{t2}}{gCOx_{t1+\Delta T} - gCOx_{t1}}$  keeps the same sign (always positive or negative, depending on the relation between the two variables). The previous periods differ because there can be a delay between the acquisition and the effective emergence of an organizational capability. This delay effect implies that there is an “interval of tolerance”, around entities which seems to have a good behavior (as illustrated in Figure 8 by the dotted channel). That enables to bypass the problem of trigger identification raised by the equivalence method.

This interval of tolerance can be considered as a regression channel, which could be found by studying the density of the points on the graphs, or in calculating distance of the points from a regression curve. Nevertheless these operations need for many calculations, and rather do not involve human intervention, whereas the experts (those who analyze the capabilities behavior and compare the learning entities) has an important role to play (he/she must check if the assumptions are relevant, for instance about the choice performance criterion, or on the choice of the interval of tolerance due to the delay effect).

A practical solution would be to let the experts select the area where entities are considered as singular, that would allow taking into account some information that only humans can analyze (for instance an experts can remove from singularities some entities: a singular newcomer could be less alarming than an older entity in difficulties for several months).

#### IV.1.3. Identification of the errors to improve organizational capability assessment

Once the errors are estimated or detected with the previous methods, it is necessary to understand why the errors occur. First of all, as mentioned before, the number of concerned entities must be studied. If it is a global error (given by the estimation methods or the impact analysis), the model design can be called into question, and it is necessary to find the sticking points (practices, requirements or resources). If it is a local error, the context of transfer or the assessment by learners can be pointed out, and the environmental causes or the human errors must be analyzed.

##### Research of model factors (based on the learning speed estimation for maturity methods)

Let consider that there is an error found by the study of the organizational behavior, according to the time (learning speed), in a maturity methods. Let assume that this error is due to a not optimal structure of knowledge, and that some antecedence links were not well established. For instance, let K113 a practice which cannot be acquired if K121 and K132 are not acquired (cf. Figure 3). How to identify this model error from the estimation of the learning speed of a singular performance of the capability?

- If there is a practice which is put at a wrong place, a major part of entities should be stuck at a given level (here K113 cannot be acquired, so the requirement E11 cannot be satisfied, and then nCOx cannot reach the level 1).
- After finding the sticking level, the error must be localized according to the resources. The focus must be done on the resource which do not reach the level 1 ( $nR_i < 1$ ), by studying if a major part of entities are stuck at this level. For the chosen example, this study among all the learning entities provides the information that the error is at the maturity level 1 of the capability and on the resource R1. The error of structure concerns therefore a practice of E11. By repeating the same processed for each practices, the problematic K113 can be identified.
- The antecedence error can then identified by comparing the successful entities with the failing entities, and by studying the difference of practices  $K_{ijz}$  acquired at the following levels. In the example, because the error occurs for K113, the study points out the difference of acquisition of each practices  $K_{12i}$  of the requirement E12 of the same resource R1. The following expression is used to identify if a practice  $K_{i(j+1)z}$  at a consecutive level must be put before the problematic practice  $K_{ijz}$  (if the difference is far from 0):

$$\sum_{\{E_i\}} \underbrace{(K_{i(j+1)z} \times K_{ijz})}_{\text{Successful entities on } K_{ijz}} - \underbrace{(K_{i(j+1)z} \times (1 - K_{ijz}))}_{\text{Failing entities on } K_{ijz}}$$

By applying this formula on each  $K_{12z}$  in the example, the antecedence links from K121 to K113 can be identified, and then K121 can be placed into E11 to guarantee a good organizational capability acquisition.

- If the study of the consecutive level is not significant, the study must be led at the upper level. Nevertheless this study must be done carefully, because of the maturity logic where learners try to follow the learning path, and do not always explore the upper level (more study is led at upper levels, more the formula loses its meaning).

The same study could be made at an upper level of knowledge granularity, by analyzing the  $E_{ij}$  instead of the  $K_{ijz}$ .

##### Research of environmental factors

When singular entities are detected (it is to say the entities whose acquired organizational capabilities generate singular performance), it is necessary to understand the origins of these singularities. A possibility is to cross the lists  $\{P_k\}_i$  of all these singular entities  $E_i$ , so as to find the shared properties of the sites with respectively outperformance and underperformance. This step enables to identify some issues due to:

- Cultural context (underperformance in specific geographical zone)

- Misunderstanding (insufficient language level can avoid a good self-assessment of capabilities for instance).
- Entity's seniority in organization (the entity is not enough mature on the practices to implement: then the different knowledge can be acquired without a real synergy between those ones, triggering an underperformance).
- Functional or product context (the practices are not adapted to all the products delivered by an entity).
- Self-assessment mistakes (a single singularity which has no commonalities with other singular sites is sometimes the result of a human error).

Nevertheless the causes of singular organizational capability's performance can also be positive and generate a source of innovation for organization. Thus outperformance can be seen as occasions to identify new good practices. Indeed an entity with a good value on the performance criterion and a weak grade on the capability model can be caused by the use of practices which create performance and are not modeled.

### **Improvement**

All the method of estimation and detection are proposed to help experts in their analysis of organizational capability behavior but not to replace their expertise, as well as to support innovative participation around organizational capability models. It is a way to detect errors parameters, to identify the cause in the modeling or the transfer phases, and prioritize the actions of correction or improvement on the content or the context of knowledge based models.

The detection of singular entities could reduce the perimeter of where communication and innovative participation (feedbacks, recommendations from users) is required to solve problem. This knowledge of singular entities enables to focus the support for organizational capabilities development, to launch local actions rather a global system more difficult to deal with (Rauffet, 2009). Moreover some vectors of collaboration, some communities of practices around organizational capability models, can be drawn, between the sites in difficulty and the sites which succeed or between the similar entities (in order to progress by neighborhood, by following the example of close successful entities).

Moreover, it can be a means to realize that some deliverables or some requirements must be rewritten, in a single loop way, to be adapted to some local context, without changing the global assessment of the transferred capability. In addition the estimation or the detection of generic error, can express a need for changing globally the content of roadmaps in a double-loop way.

Finally all the knowledge on the presented parameter provides a more finely-shaded analysis for expert and manager who uses the data given by knowledge based assessment to diagnose the capabilities and the state of the organization.

## **IV.2. Development of a tool and illustration**

The previous methods use sometimes a huge amount of data, and their implementation needs for automation. This automation would enable to cross and mine data, or visualize the results of analysis, so to help expert to correct organizational capability's knowledge based models, to support locally entities in difficulty, and to take the identified errors into account when capabilities' assessments are consolidated for organizational diagnosis.

### **IV.2.1. Development choices and overview**

To achieve the automation of some methods previously described, a demonstrator was elaborated:

- A part of it was developed in VBA (Visual Basic for Applications). This framework was chosen because it is easily implementable in industrial organization, because it is quite well integrated to Excel or Access, that allow a data mining among an average database (hundred of entities, with dozens of capabilities assessment, dozens of performances indicators, and dozens of properties). This part is focused on the study of statistical dependency between performance and capabilities, as well as the learning speed, to observe the stagnation and the impact of organizational capabilities onto the organization.
- Moreover, another part of the tool uses some Google's API. The choice was motivated by the ease of portability (it needs only for a web browsers and an internet connection). This part implements multi-criteria

graphical and geographical views, in order to help experts to visualize the results of analysis, to identify the singular entities, and to look for the environmental origins of these singularities. In addition, it provides some functionalities to gather entities into communities of practices around organizational capabilities models, to represent some collaboration vectors between similar entities (to progress by neighborhood and to support entities in difficulties), and to launch actions of participative innovation (by easing the communication to these constituted communities of practices).

#### IV.2.2. Example of the tool usage

5 steps roadmapping (Blanc and Monomakhoff, 2008) is an organizational capability maturity method, designed by MNM Consulting. Supported by a formalism, the roadmap, and a software tool, it has been implemented across the whole Valeo Group for four years. It is used to codify and transfer good practices with knowledge models allied roadmaps, to integrate new sites on some corporate standards, and to assess locally and globally the organizational capabilities. The research and development works around this framework occur in the project Pilot2.0, supported by the French National Agency for Research since December 2007 (ANR, 2007).

For illustrating the use of the developed tool, the framework of this industrial and academic project is taken. The data on organizational capability and performance indicator are fictive so as to be able to present a simplified case in this paper, but the contextual information are based on the reality of the organization V. The relations between variables were implemented by introducing some random noise, so as to create singularities which must be detected by the tool. A test on real data must be led further.

Let an organization V which is composed of one hundred production plants. These plants are specialized in many different products (compressors, lights, air conditioning, etc), are located worldwide, and are heterogeneous on their seniority inside the organization, their industrial culture... To share the strategic objectives with these plants and develop collective capabilities around them, the organization V uses roadmaps to structure, transfer and assess organizational capabilities about some production stakes (compliance with total quality standards and 6 sigmas method, implementation of preventive maintenance in workshops, Involvement of workers by using 5S and other Kaizen methods, Security at work...). The assessment of the implementation of these organizational capabilities must provide to this organization some relevant information on its state, on its strengths and its weaknesses. Nevertheless, some human and organizational factors can noise this measurement, and must be identified and corrected to sustain a reliable organizational diagnosis on these production stakes.

*First of all, the impact of these production roadmaps on the performance of organization is studied, so as to verify the accurate behavior of these models and to detect some potential global design errors.*

A MLR-base impact analysis is done (cf. paragraph III.1.2.) between Performance Indicators (Overall Equipment Effectiveness, Machine Capability, number of accidents at work, Parts Per Million ...) and the production roadmaps. On the figure 9, the implementation of the roadmap Total Quality/6 sigmas have some impacts on machine capability, OOE, and PPM.

	RM_Maintenance	RM_6_sigmas	RM_securite	RM_Achat
SignIP(RM)	TRS	Capabilite	-IF_pr_AT	%_cmd_livrees_a
	-PPM	TRS	-Capabilite	
	Capabilite	-PPM		
	RM_Maintenance	RM_6_sigmas	RM_securite	RM_Achat
PPM	-24%	-20%	4%	-3%
IF_pr_AT	1%	8%	-44%	0%
TRS	36%	36%	-1%	-6%
Capabilite	13%	61%	-10%	0%
%_cmd_livrees_a_tp	3%	-4%	-4%	36%

Figure 9: extract of impact analysis based on MLR

These results could be assumed by experts, the automation is only here to confirm their intuition or to indicate some effects not planned (for instance, the roadmap security seems to have a little negative effect on machine capability). Moreover, this analysis provides the associated performance criteria for studying each organizational capability (here modeled by roadmaps) and compare plants according to these criteria.

*The experts can then decide to study in detail the behavior of all entities on a given roadmap, by choosing, according to his/her experience or from the previous analysis, a performance criterion. This criterion enables to detect local transfer errors.*

For instance, the expert could choose to study the behavior of entities on the roadmap 6 sigmas, according to their machine capability rate (cf. Figure 10). Thanks to a graphical visualization and according to its knowledge on the seniority and some other contextual properties of entities (some filters are put to remove or insert entities from the graphic), the expert can select all the plants which seems to be singular, it is to say with a performance not adequate to their maturity level. Entities with underperformance must be distinguished from entities with out-performance.

For the example, the maturity levels are studied (this grade is generally used to assess the progress on roadmap). However coverage could be also used in the same manner (by segmenting the percentage of practices to acquire instead of dealing with maturity levels). Furthermore, the roadmap could be implemented with some a priori objectives on performance. In this case, the graphic view can also indicate to expert if the cloud of points and the regression channel are coherent with the waited performance of roadmaps.

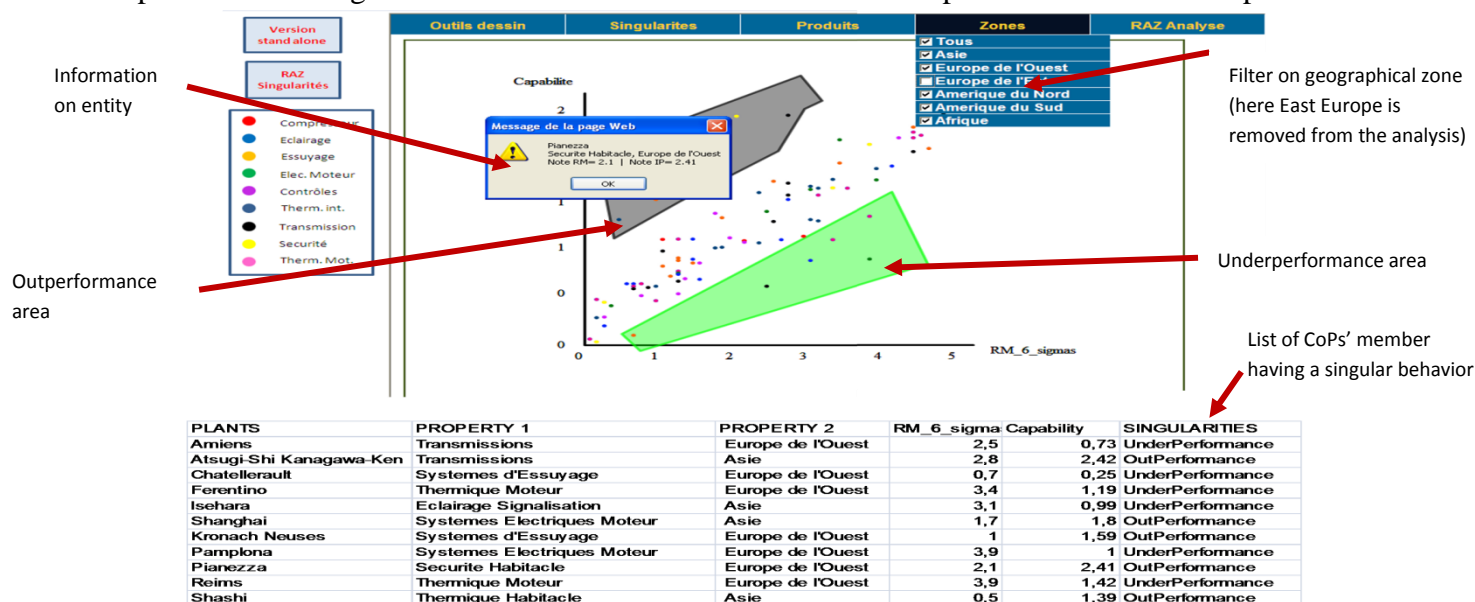


Figure 10: Graphical visualization and selection of singular entities

*Once the singular plants are detected, the expert tries to understand what causes these errors, and if the problem are endemic to a single entities or shared by plants with some common characteristics. Thanks to a set of filter and a dynamic crossed table, the environmental causes can be understood.*

As emphasized in the list of singularities of Figure 10, many plants from West Europe are singular, and most of these ones present underperformance.

*Finally the expert and the learners can use the output previous analysis to visualize, graphically or geographically (to take the cultural and neighborhood aspects into account, cf. Figure 10) some collaboration vectors and to gather similar entities by communities of practices (according to their characteristics, or their singular behavior).*

The term of communities of practices (Wenger, 2000) can be used here. Indeed, people are obviously grouped into not very formal structure around knowledge models, which symbolized their common interests around strategic issues in the field of production, information system, people involvement... Even if the organization imposes in these CoPs the subject of concerns, people are free to learn from each other, they acquire in their progression a common language, and they identify people who can help them to progress further.



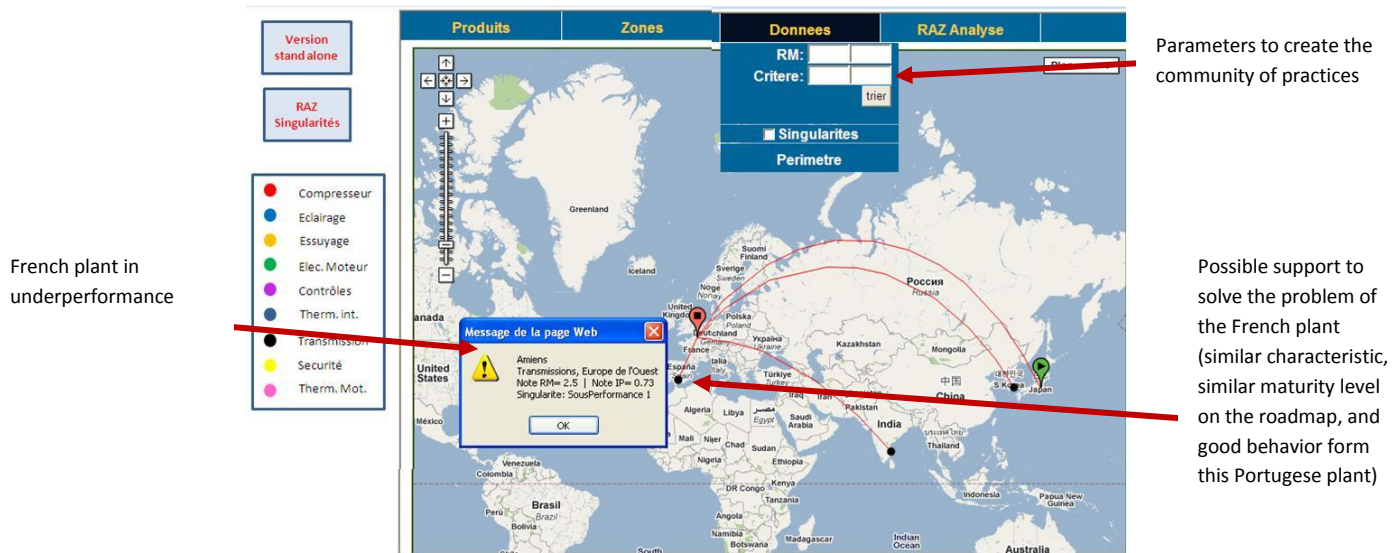


Figure 11: Visualization of CoPs for finding good neighbor

These lists of communities of practices can be used to launch focused brainstorming sessions around roadmap adaptation in particular contexts, or to put a weight on the entities which presents some errors (for the consolidation at upper organizational levels). Moreover, these visualization help entities to find the good neighbor (in term of roadmap behavior and similarity of properties) to track to progress in a good way. In addition to the path drawn by the maturity level, a progression can therefore be made according to the distance towards successful neighbors.

The methods and the tool were presented and illustrated partially in a case study. The figure 12 positions the answers that the tool and the previous methods bring to support the methodology, in the part focused on making the organizational capability assessments more reliable (cf. steps 1, 2 and 3 of Figure 2, and Figure 5).

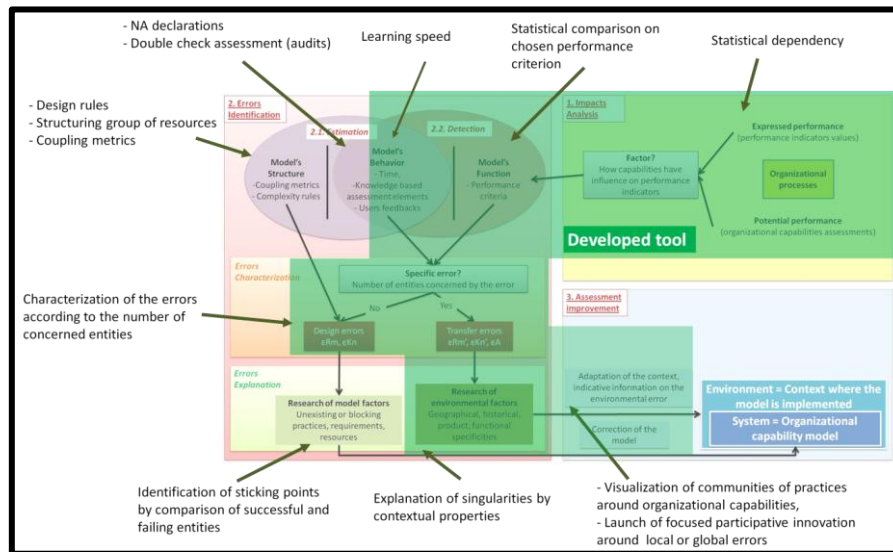


Figure 12: Positions of the proposed methods and tool

The next paragraphs will discuss how these assessments and the knowledge on their errors can be used for the organizational diagnosis, and how they could be aggregated and consolidated for helping organization to understand its capabilities.

## V. Discussion: interest of the methodology, the methods and the tool for supporting organizational diagnosis

The first three steps presented in the methodology (cf. figure 5) and supported by methods and tools developed in this paper (cf. figure 12), are used to make more reliable the assessments of organizational capabilities based on knowledge models. However the finality of the methodology is out of there. The assessment reliability has

only a sense if the assessment is used. It is why the methodology has a fourth steps, called “aggregation/consolidation”.

Indeed the obtained reliable organizational capability assessments will be used for two processes:

- they will support the organizational diagnosis, by helping expert to understand:
  - what grades means really,
  - how potential errors can noise the signal they receive from the knowledge models evaluation (for instance by putting a weight to some identified communities of practices where the context provides too many practices or resources not applicable),
  - how they can trust figures when they cross many measurements of modeled organizational capabilities to obtain new indicators on some capabilities not modeled, or when they tried to know if they can make several different entities work together (with different context which can impact on the meaning of the organizational capability assessment). The assessments and their error must be therefore aggregated and consolidated together.
- they will be injected again in the loop for making assessment more reliable (steps 1, 2, 3) so as to base the impact analysis and all the comparisons between potential and real performance more accurate, in a virtuous circle.

The improvement of the assessment (due to the correction of the errors in the knowledge models, to the adaptation to these models to some specific and problematic context, or at least to the knowledge of these errors to take them into account when evaluations are consolidated) aims at giving a relevance and an accuracy to the indicators deduced from this assessment.

These indicators, deduced from the metrics described in part II, can be used for:

- controlling the progress of entities on the organizational capabilities (for instance by studying the dispersion of maturity of the resources composing an organizational capability)
- managing multi-objectives, multi-disciplinary (and therefore “multi-capability”) subjects: for instance the decision to launch a new product can be taken given the state of entities on their production capabilities (are they enough mature on the acquisition and the standardization of methods for quality, agility...?) and on their technological capabilities (are the product design and the chosen material enough mature to guarantee a product satisfying the customers and profitable for the organization?).
- deducing the degree of interoperability (Rauffet, 2009) for launching collaborations org reorganizing the organizational structure (for instance by mutualizing the purchasing department between several plants, according to their maturity degree on their product reference and their relationships with suppliers).

As illustrated in Figure 13, these assessments are thus used to process the organizational diagnosis, it is to say the state of the strengths and the weaknesses of the internal resources, as defined by (Learned et al., 1960). This diagnosis enables to articulate and implement a relevant strategy, where the power of organization (the knowledge acquisition, the resources synergy, and finally the emergence of organizational capabilities, as described in figure 1) is transformed into efficient activities.

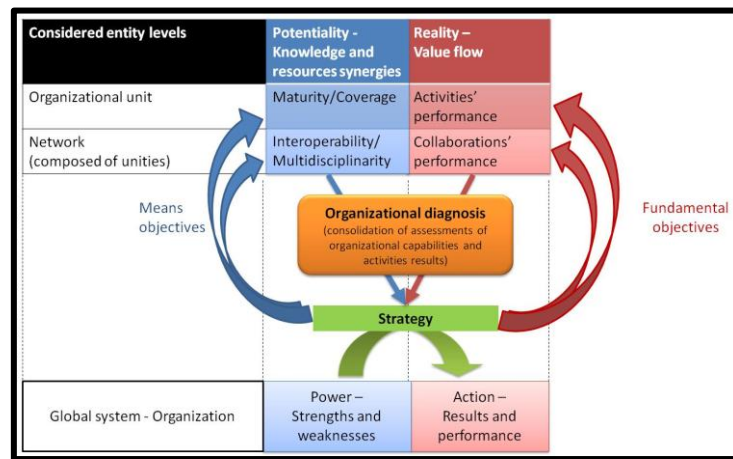


Figure 13: Use of organizational capabilities assessment in organizational diagnosis

## VI. Conclusion

With the implementation of ISO norms or maturity models, like CMMI or 5 steps, the management of organizational capabilities and the organizational diagnosis are based on the assessments given by knowledge based models. However, these models, which gather and structure good practices to help organizational entities to acquire collective capabilities, play on design assumptions and give an important responsibility to the functional experts. Human errors can occur, either in the modeling or in the application phases. In a more general view, one of the major challenge of Knowledge Management (knowledge modeling and reuse with transfer of good practices) and Organizational Capabilities approaches is to assess the value of its implementation. How these efforts are benefic for the organization? How to trust the functional experts and their knowledge modeling, in an open loop, without control means?

This paper aims at answering these issues (cf. Figure 14). Part I proposes a methodology to help organizations for identifying the possible errors which occur when organizations implement systematically organizational capabilities, for correcting these errors or at least for taking them into account. That would enable a more reliable organizational diagnosis. Part II makes explicit the knowledge based models of assessment as well as their possible error parameters. Then part III provides some methods and a tool to estimate, detect, identify and correct these errors. Finally part IV discuss the use of consolidated organizational capability assessments for supporting the organizational diagnosis, and for making the assessment more and more reliable, in a virtuous cycle.

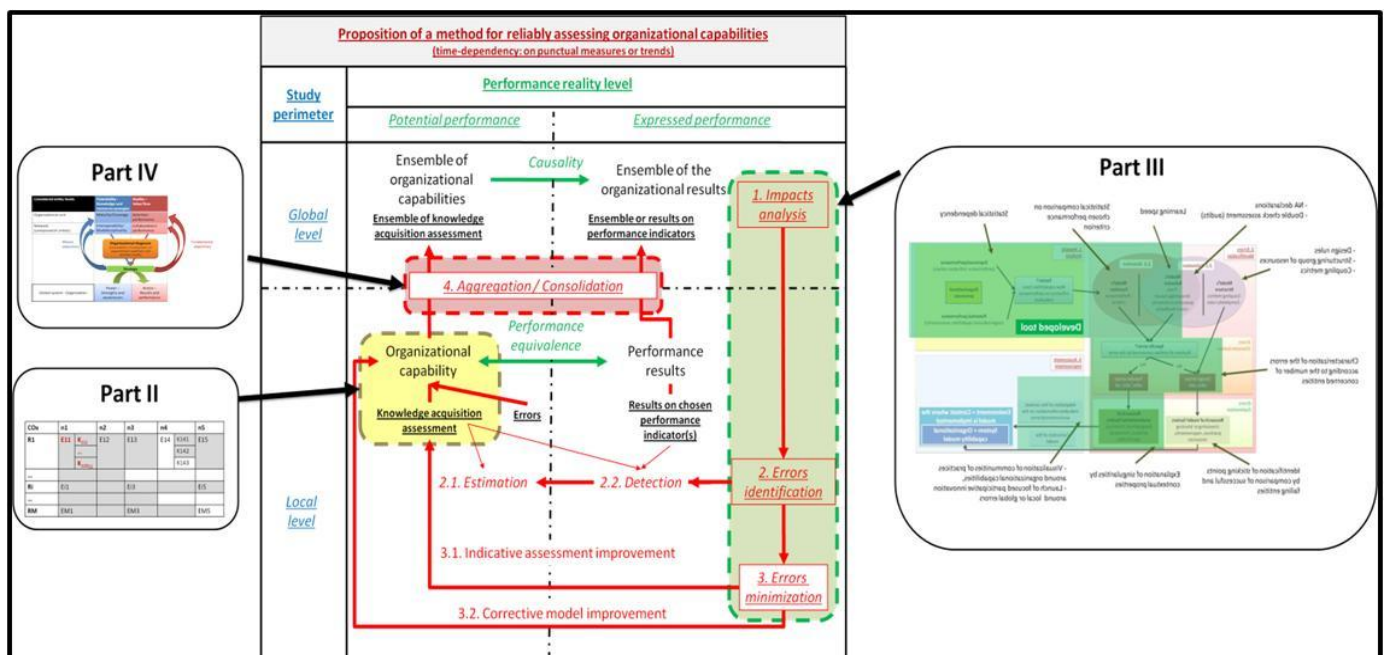


Figure 14: Synthesis of the paper



Some presented methods are not currently automated (for instance the study of the learning speed, etc) and will need for a future development. Moreover, so as to adjust the methods and the tool, a real test should be made.

## VII. Acknowledgements

Authors acknowledge the French National Agency of Research, which supports and funds Pilot2.0 project (ANR, 2007) and the current research works. It involves laboratories (IRCCyN and M-LAB), companies (MNM Consulting, Valeo) and institutional partners (General Council of Vaucluse). The aim of this partnership is to provide a generic method for organizational capabilities development, to improve existing tools and to deploy them on other types of organizational structures.

## VIII. Reference

1. Helfat C.E, Peteraf, M.A., 2003. The dynamic resource-based view: capability lifecycles. *Strategic Management Journal*, Vol. 24, Issue 10
2. Ansoff H.I, 1965. *Corporate Strategy*. McGraw-Hill, New York
3. Learned, E.P., Christensen, C.R., Andrews, K.E., Guth, W.D., 1965. *Business Policy: Text and Cases*. Irwin, Homewood
4. Renard, L. et Saint Amant, G., 2003. Capacité, capacité organisationnelle et capacité dynamique : une proposition de définitions. *Les cahiers du Management Technologique*
5. Lorino, P., 2001. *Méthodes et Pratiques de la Performance*, Editions d'Organisation
6. de Pablos P.O., Lytras M.D., 2008. Competencies and human resource management: implications for organizational competitive advantage. *Journal of Knowledge Management*, Vol. 12, Issue 6
7. Rauffet P., Labrousse M., Da Cunha C., Bernard A., 2009. Progress management in performance-driven systems: study of the 5Steps® roadmapping, a solution for managing organizational capabilities and their learning curves. INCOM conference
8. Saint-Amant G.E., Renard L., 2004. Premier référentiel de connaissances associées aux capacités organisationnelles de l'administration électronique. *Management International*, Vol.9
9. Lusthaus C., Anderson G., Murphy E., 2003. Institutional assessment, A framework for strengthening organizational capability for IDRC's Research partners
10. Watson D., 2009. Monitoring and evaluating capacity and capacity development, embracing innovative practice, *capacity.org's journal*, issue 38
11. SEI, 2010. CMMI website. <http://www.sei.cmu.edu/cmmi/>
12. Monomakhoff, N., Blanc, F., 2008. La méthode 5Steps® : Pour déployer efficacement une stratégie. AFNOR
13. ISO, 2010. ISO website. <http://www.iso.org/iso/home.htm>
14. ITIL, 2010. ITIL website. <http://www.itil-officialsite.com/home/home.asp>
15. Beguin P., Cerf M., 2004. Formes et enjeux de l'analyse de l'activité pour la conception des systèmes de travail, *Activités*
16. Guillevic C., 1993. *Psychologie du travail*. Nathan Université
17. Berio G., Harzallah M., 2007. Towards an integrating architecture for competence management. *Computer In Industry*, issue 58.
18. Boucher X., 2003. Formal diagnosis of multi-enterprises systems of competencies. ICE Conference.
19. Houé B., Grabot B., Geneste L., 2009. Competence management for business integration. INCOM Conference.
20. Boumane A., Talbi A., Tahon C., Bouami D., 2006. Contribution à la modélisation de la compétence. MOSIM Conference.
21. Pépiot G., Cheikhrouhou N., Furbringer J.M., Glardon R., 2007. UECML: Unified Enterprise Competence Modelling Language. *Computer In Industry*, Issue 58

22. Harzallah M., Vernadat F., 2002. IT-based competency modeling and management: from theory to practice in enterprise engineering and operations, Computer In Industry, Issue 48.
23. Gonzalez-Ramirez, Marle F., Bocquet J.C., 2008. Assessing project maturity : a case study, PMI Research Conference, Poland
24. Xu Y., Bernard A., Knowledge organization through statistical computation: A new approach. Knowledge Organization Vol. 36, Issue 4
25. Rauffet P., Da Cunha C., Bernard, A., 2009. Sustainable organizational learning in group : a digital double-loop system based on knowledge maturity and performance assessment. DET Conference
26. Wenger, E., 2000. Communities of practice and social learning system. Organization, Vol. 7 Issue 2
27. Rauffet P., Da Cunha C., Bernard, A., 2009. Designing and managing Organizational Interoperability with organizational capabilities and roadmaps. IESA Conference